AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

LISTING OF CLAIMS:

1. (currently amended) An ink consumption condition detection method for detecting an ink consumption condition in an ink container loaded in an ink jet recording apparatus having a recording head for jetting ink drops, wherein said ink consumption condition in said ink container is detected using a piezo-electric device having a piezo-electric element during a non-recording state of said recording head,

wherein said piezo-electric device further has a vibrating plate on one side of which said piezoelectric element is arranged, and a cavity forming member having a cavity which is arranged on the other side of said vibrating plate,

~~wherein said vibrating plate can come in contact with said liquid in said liquid container via said cavity,~~

wherein said piezo-electric element of said piezo-electric device has a vibration part, and said piezo-electric device outputs a signal indicating a residual oscillating state of said vibration part under free oscillation, ~~and~~

wherein said vibration part of said piezo-electric element contacts with an ink in said ink container via said cavity, said cavity defining an area of said vibration part, and

wherein said ink consumption condition is detected based on a change of said residual oscillating state of said vibration part under free oscillation corresponding to ink being consumed.

2. (Original) An ink consumption condition detection method according to claim 1, wherein said ink consumption condition in said ink container is detected using said piezo-electric device during a maintenance operation for cleaning said recording head.

3. (Original) An ink consumption condition detection method according to claim 1, wherein said ink consumption condition in said ink container is detected using said piezo-electric device during an operation for feeding or ejecting a recording medium, to which ink is jetted from said recording head, to or from said recording apparatus.

4. (Original) An ink consumption condition detection method according to claim 1, wherein said ink consumption condition in said ink container is detected using said piezo-electric device when power of said recording apparatus is turned on.

5. (Original) An ink consumption condition detection method according to claim 1, wherein said ink consumption condition in said ink container is detected using said piezo-electric device during a period from turning said recording apparatus off to a stop of said recording apparatus.

6. (Original) An ink consumption condition detection method according to claim 1, wherein said ink container is an ink cartridge loaded on a carriage for moving said recording head back and forth in a removable state, and said ink consumption condition in said ink cartridge is detected using said piezo-electric device during a period in which said carriage is stopped.

7. (Original) An ink consumption condition detection method according to claim 6, wherein said ink consumption condition in said ink cartridge is detected using said piezo-electric device after a predetermined time lapses from the beginning of a stop state of said carriage.

8. (Original) An ink consumption condition detection method according to claim 1, wherein said piezo-electric device detects changes in acoustic impedance, thereby detects said ink consumption condition in said ink container.

9. (previously presented) An ink consumption condition detection method according to claims 8, wherein said piezo-electric element of said piezo-electric device has a vibration part, wherein said piezo-electric element of said piezo-electric device detects changes in said acoustic impedance on the basis of counter electromotive force generated by residual vibration remaining in said vibration part, thereby detects said ink consumption condition in said ink container.

10. (Original) An ink consumption condition detection method according to claim 1, further comprising the steps of:

storing information of said ink consumption condition in said ink container detected by said piezo-electric device in a storage unit mounted on said ink container,

reading said information of said ink consumption condition stored in said storage unit, and

judging whether a detection of said ink consumption condition in said ink container should be executed or not on the basis of said read information of said ink consumption condition.

11. (Original) An ink consumption condition detection method according to claim 1, wherein said ink container is an ink cartridge loaded on a carriage for moving said recording head back and forth in a removable state,

said method comprising:

a consumption condition detection step of detecting, in a non-recording state of said recording head, said ink consumption condition in said ink cartridge by said piezo-electric device, and

a reconfirming step of redetecting said ink consumption condition in said ink cartridge by said piezo-electric device after detection of absence of ink in said ink cartridge by said consumption condition detection step.

12. (Original) An ink consumption condition detection method according to claim 11, wherein said reconfirmation step comprises:

a carriage moving step of moving said carriage after absence of ink in said ink cartridge is detected by said consumption condition detection step, and

a consumption condition redetection step of redetecting said ink consumption condition in said ink cartridge in a predetermined timing.

13. (previously presented) An ink consumption condition detection method according to claim 12,

wherein said carriage moving step moves said carriage at a faster speed than a speed for moving said carriage during a recording operation.

14. (previously presented) An ink consumption condition detection method according to claim 12,

wherein a shock is given to said ink cartridge during moving said carriage by said carriage moving step.

15. (previously presented) An ink consumption condition detection method according to claim 12,

wherein said consumption condition redetection step is executed when a predetermined time passes after said carriage moving step ends.

16. (previously presented) An ink consumption condition detection method according to claim 12,

wherein said consumption condition redetection step is executed during moving said carriage by said carriage moving step.

17. (Original) An ink consumption condition detection method according to claim 16, wherein said carriage moving step moves said carriage back and forth, and, when said carriage almost returns and moves from a forward path to a backward path, said consumption condition redetection step redetects said ink consumption condition.

18. (Original) An ink consumption condition detection method according to claim 16, wherein said carriage moving step moves said carriage back and forth, and, immediately after said carriage ends moving on a forward path and starts moving on a backward path, said consumption condition redetection step redetects said ink consumption condition.

19. (previously presented) An ink consumption condition detection method according to claim 12,

wherein said reconfirmation step is executed several times during moving said carriage by said carriage moving step, and presence or absence of ink in said ink cartridge is decided on the basis of detection results of said reconfirmation steps.

20. (Original) An ink consumption condition detection method according to claim 19, wherein said reconfirmation step is executed several times, and, when presence of ink is detected in said consumption condition redetection step more than a predetermined count, it is decided that ink exists in said ink cartridge.

21. (Original) An ink consumption condition detection method according to claim 19, wherein said reconfirmation step is executed several times, and presence or absence of ink in said ink cartridge is decided on the basis of a mean value of measured results of said consumption condition redetection steps.

22. (Original) An ink consumption condition detection method according to claim 1, wherein measuring timing of said ink consumption condition is controlled on the basis of an operation history of said ink jet recording apparatus.

23. (previously presented) An ink consumption condition detection method according to claim 22, wherein a measuring frequency is increased according to cumulation of operations of said ink jet recording apparatus.

24. (Original) An ink consumption condition detection method according to claim 23, wherein said cumulation of operations is a cumulative driving time of a carriage on which said recording head is loaded.

25. (Original) An ink consumption condition detection method according to claim 22, wherein a measurement of said ink consumption condition is executed immediately when said measuring timing of said ink consumption condition comes after a predetermined time elapses from a point of time when a carriage on which said recording head is loaded moves last.

26. (Original) An ink consumption condition detection method according to claim 22, wherein, when said measuring timing of said ink consumption condition comes before a predetermined time elapses from a point of time when a carriage on which said recording head is loaded moves last, measurement is executed immediately after said predetermined time elapses.

27. (Original) An ink consumption condition detection method according to claim 22, wherein, when said measuring timing of said ink consumption condition comes after a predetermined time elapses from of point of time when a carriage on which said recording head is loaded moves last, a measuring interval is shortened.

28. (Original) An ink consumption condition detection method according to claim 22, wherein, when said measuring timing of said ink consumption condition comes before a

predetermined time elapses from a point of time when a carriage on which said recording head is loaded moves last, a measuring interval is increased.

29. (Original) An ink consumption condition detection method according to claim 23, wherein said cumulation of operations is a cumulative driving time of said recording head.

30. (Original) An ink consumption condition detection method according to claim 23, wherein said cumulation of operations is a measuring count of said ink consumption condition.

31. (Original) An ink consumption condition detection method according to claim 22, wherein a history memory installed in said ink jet recording apparatus or said ink container stores at least one of a cumulative time of operations of said ink jet recording apparatus and a cumulative measuring count.

32. (Original) An ink consumption condition detection method according to claim 31, wherein said history memory further stores past measurement histories using said piezo-electric device.

33. (previously presented) An ink consumption condition detection method according to claim 1,

wherein said piezo-electric device has a vibration part including said piezo-electric element, and

wherein said piezo-electric device measures a periodic peak value of a waveform of counter electromotive force generated by residual vibration remaining in said vibration part by a predetermined number of said periodic peak values from a predetermined point of time, and said piezo-electric device measures more number of said periodic peak values than said predetermined number of said periodic peak values in subsequent detection of said ink consumption condition, and thereby detects said ink consumption condition.

34. (Original) An ink consumption condition detection method according to claim 33, wherein said periodic peak value of said waveform of counter electromotive force is measured by increasing said predetermined number of values from said predetermined point of time in accordance with increasing of a detection count of said ink consumption condition in the ink container, and thereby said ink consumption condition is detected.

35. (Original) An ink consumption condition detection method according to claim 33, wherein said ink jet recording apparatus or said ink container has a storage memory, and said storage memory stores a measurement history of said ink consumption condition of said piezo-electric device.

36. (Original) An ink consumption condition detection method according to claim 1, wherein said ink container is an ink cartridge loaded on said ink jet recording apparatus in a removal state.

37. (Original) An ink consumption condition detection method according to claim 1, further comprising a consumption condition calculation process of calculating said ink consumption condition in said ink container by calculating said ink consumption used in said ink jet recording apparatus, and

wherein said piezo-electric device detects whether an ink level in said ink container passes a measuring position level which is an installation position of said piezo-electric element and thereby detects said ink consumption condition, and

wherein said consumption condition calculation process monitors said ink consumption condition in said ink container, and, when it is judged by said consumption condition calculation process that said ink level in said ink container approaches said measuring position level, said piezoelectric device detects said ink consumption condition in said container.

38. (Original) An ink consumption condition detection method according to claim 37, wherein said ink level in said ink container is detected based on either a calculated result information of said ink consumption condition in said ink container calculated by said consumption condition calculation process or a measured result information of said ink consumption condition in said ink container measured by said piezo-electric device.

39. (Original) An ink consumption condition detection method according to claim 38, wherein, when an ink residue on said ink level reaches a predetermined ink residue, said ink jet recording apparatus performs a peripheral operation in accordance with said ink residue.

40. (Original) An ink consumption condition detection method according to claim 39, wherein said predetermined ink residue is an ink residue set as ink end, and, when said ink end is detected, said ink jet recording apparatus performs a low ink processing operation.

41. (Original) An ink consumption condition detection method according to claim 37, wherein said ink consumption condition is not measured by said piezo-electric device until said ink residue calculated by said consumption condition calculation process reaches an amount in a neighborhood of said measuring position level.

42. (Original) An ink consumption condition detection method according to claim 37, wherein a measuring frequency of said ink consumption condition by said piezo-electric device is lowered until said ink residue calculated by said consumption condition calculation process reaches an amount in a neighborhood of said measuring position level.

43. (Original) An ink consumption condition detection method according to claim 37, wherein a measuring frequency of said ink consumption condition by said piezo-electric device

is increased after said ink residue calculated by said consumption condition calculation process reaches an amount in a neighborhood of said measuring position level.

44. (Original) An ink consumption condition detection method according to claim 1, further comprising a consumption condition calculation process of calculating said ink consumption condition in said ink container by calculating said ink consumption used in said ink jet recording apparatus, and

wherein said consumption condition calculation process and said detection process of said ink consumption condition by said piezo-electric device are used together, and

wherein said piezo-electric device detects whether an ink level in said ink container passes a measuring position level which is an installation position of said piezo-electric element or not, and thereby detects said ink consumption condition, and

wherein, after detecting by said piezo-electric device that said ink level passes said measuring position level, ink end or no-end is decided based on an average of a plurality of measured results of said ink consumption condition measured by said piezo-electric device.

45. (Original) An ink consumption condition detection method according to claim 44, wherein a measuring frequency of said piezo-electric device is lowered until first passing of said ink level through said measuring position level is measured by said piezo-electric device.

46. (currently amended) An ink jet recording apparatus comprising:

a recording head configured to jet ink drops;

an ink cartridge configured to feed ink to said recording head;

a piezo-electric device having a piezo-electric element configured to detect an ink consumption condition in said ink cartridge, said piezo-electric device further having a vibrating plate on one side of which said piezo-electric element is arranged, and a cavity forming member having a cavity which is arranged on the other side of said vibrating plate~~, said vibrating plate being able to come in contact with said liquid in said liquid container via said cavity~~; and

a control unit for controlling said piezo-electric device so as to detect said ink consumption condition when said recording head is in a non-recording state,

wherein said piezo-electric element of said piezo-electric device has a vibration part, and said piezo-electric device outputs a signal indicating a residual oscillating state of said vibration part under free oscillation, ~~and~~

wherein said vibration part of said piezo-electric element contacts with an ink in said ink cartridge via said cavity, said cavity defining an area of said vibration part, and

wherein said ink consumption condition is detected based on a change of said residual oscillating state of said vibration part under free oscillation corresponding to ink being consumed.

47. (Original) An ink jet recording apparatus according to claim 46, wherein said piezo-electric device detects changes in acoustic impedance, thereby detects said ink consumption condition in said ink container.

48. (Original) An ink jet recording apparatus according to claim 47, wherein said piezo-electric device has a vibration part including a piezo-electric element, and

wherein said piezo-electric device detects changes in said acoustic impedance on the basis of counter electromotive force generated by residual vibration remaining in said vibration part, thereby detects said ink consumption condition in said ink container.

49. (Previously Presented) An ink jet recording apparatus according to claim 46, further comprising a storage unit for storing said ink consumption condition in said ink cartridge which is detected by said piezo-electric device.

50. (Original) An ink jet recording apparatus according to claim 49, wherein said storage unit is mounted on said ink cartridge.

Claim 51 (canceled)

52. (Original) An ink jet recording apparatus according to claim 46, further comprising a carriage moving with said recording head and said ink cartridge both of which are loaded on said carriage,

wherein said control unit controls said piezo-electric device so as to redetect said ink consumption condition in said ink cartridge after said piezo-electric device detects absence of ink in said ink cartridge when said recording head is in a non-recording state.

53. (Original) An ink jet recording apparatus according to claim 52, wherein said control unit moves said carriage after detection of absence of ink in said ink cartridge by said piezo-electric device and controls said piezo-electric device so as to redetect said ink consumption condition in said ink cartridge in predetermined timing.

54. (previously presented) An ink jet recording apparatus according to claim 53,

further comprising a shock unit configured to give a shock to said ink cartridge during movement of said carriage.

55. (Previously Presented) An ink jet recording apparatus according to claim 49, wherein said storage unit is mounted on said piezo-electric device.

56. (currently amended) An ink jet recording apparatus comprising:

a recording head for jetting ink drops;

an ink cartridge for feeding ink to said recording head;

a piezo-electric device for detecting an ink consumption condition in said ink cartridge; and

a control unit for controlling said piezo-electric device so as to detect said ink consumption condition when said recording head is in a non-recording state,

wherein said piezo-electric device has a piezo-electric element mounted on the outside of said ink cartridge, wherein said piezo-electric element of said piezo-electric device has a vibration part, and said piezo-electric device outputs a signal indicating a residual oscillating state of said vibration part under free oscillation, ~~and~~

wherein said piezo-electric device includes a cavity, said vibration part of said piezo-electric element contacts with an ink in said ink cartridge via said cavity, said cavity defining an area of said vibration part, and

wherein said ink consumption condition is detected based on a change of said residual oscillating state of said vibration part under free oscillation corresponding to ink being consumed.

57. (Previously presented) An ink consumption condition detection method for detecting an ink consumption condition in an ink container loaded in an ink jet recording apparatus having a recording head for jetting ink drops,

wherein said ink consumption condition in said ink container is detected using a piezo-electric device having a piezo-electric element during a non-recording state of said recording head,

wherein said piezo-electric device has a vibration part including said piezo-electric element,

wherein said piezo-electric device measures a periodic peak value of a waveform of counter electromotive force generated by a residual vibration remaining in said vibration part by a predetermined number of said periodic peak values from a predetermined point of time, and said piezo-electric device measures more number of said periodic peak values than said predetermined number of said periodic peak values in subsequent detection of said ink consumption condition and thereby detects said ink consumption condition, and

wherein said ink consumption condition in said ink container is detected using said piezo-electric device during maintenance operation for cleaning out ink in said recording head.

58. (previously presented) An ink consumption condition detection method, comprising:

detecting an ink consumption condition in an ink container loaded in an ink jet recording apparatus having a recording head for jetting ink drops,

wherein said ink consumption condition in said ink container is detected using a piezo-electric device having a piezo-electric element during a non-recording state of said recording head,

wherein said piezo-electric device has a vibration part including said piezo-electric element,

wherein said piezo-electric device measures a periodic peak value of a waveform of counter electromotive force generated by residual vibration remaining in said vibration part by a predetermined number of said periodic peak values from a predetermined point of time, and said piezo-electric device measures more number of said periodic peak values than said

predetermined number of said periodic peak values in subsequent detection of said ink consumption condition, and thereby detects said ink consumption condition,

storing information of said ink consumption condition in said ink container detected by said piezo-electric device in a storage unit mounted on said ink container,

reading said information of said ink consumption condition stored in said storage unit, and

judging whether a detection of said ink consumption condition in said ink container should be executed or not on the basis of said read information of said ink consumption condition.

59 (Previously Presented) An ink jet recording apparatus comprising:

a recording head for jetting ink drops;

an ink cartridge for feeding ink to said recording head;

piezo-electric device for detecting an ink consumption condition in said ink cartridge; and

a control unit for controlling said piezo-electric device so as to detect said ink consumption condition when said recording head is in a non-recording state,

wherein said piezo-electric device has a vibration part including a piezo-electric element, and

wherein said piezo-electric device measures a periodic peak values of a waveform of counter electromotive force generated by residual vibration remaining in said vibration part by a predetermined number of said periodic peak values from a predetermined point of time, and said

piezo-electric device measures more number of said periodic peak values than said predetermined number of said periodic peak values in subsequent detection of said ink consumption condition, and thereby detects said ink consumption condition, and

a storage unit for storing said ink consumption condition in said ink cartridge which is detected by said piezo-electric device.

60. (Previously Presented) An ink jet recording apparatus according to claim 59, wherein said storage unit is mounted on said ink cartridge.

61. (Previously Presented) An ink consumption detection method according to claim 12 wherein a shock is given to said ink cartridge during moving said cartridge by said carriage moving step.

62. (Previously Presented) An ink jet recording apparatus according to claim 53, further comprising a shock unit configured to give a shock to said ink cartridge during movement of said carriage.

63. (Previously Presented) An ink consumption condition detection method for detecting an ink consumption condition in an ink container loaded in an ink jet recording apparatus having a recording head for jetting ink drops,

wherein said ink consumption condition in said ink container is detected using a piezo-electric device having a piezo-electric element during a non-recording state of said recording head,

wherein said ink consumption condition in said ink container is detected using said piezo-electric device during a maintenance operation for cleaning out ink in said recording head.

64. (previously presented) An ink consumption condition detection method for detecting an ink consumption condition in an ink container loaded in an ink jet recording apparatus having a recording head, the method comprising:

abstaining from jetting ink drops from said recording head in a non-recording state; and

detecting an ink consumption condition during said non-recording state of said recording head by vibrating a vibrating plate having a piezo-electric element arranged on one side of the vibrating plate, in which said vibrating plate comes into contact with liquid in said liquid container via a cavity formed in a cavity forming member which is arranged on an opposite side of said vibrating plate as said piezo-electric element.

65. (previously presented) An ink consumption condition detection method for detecting an ink consumption condition in an ink container loaded in an ink jet recording apparatus having a recording head, wherein said ink consumption condition in said ink container is detected using a piezo-electric device having a piezo-electric element, said method comprising:

abstaining from jetting ink drops from said recording head in a non-recording state; and

measuring a periodic peak value of a waveform of counter electromotive force generated by a residual vibration remaining in a vibration part by a predetermined number of said periodic peak values from a predetermined point of time, such that when said piezo-electric device measures more number of said periodic peak values than said predetermined number of said periodic peak values in subsequent detection of said ink consumption condition, said ink consumption condition is thereby detected.

66. (previously presented) An ink consumption condition detection method for detecting an ink consumption condition in an ink container loaded in an ink jet recording apparatus having a recording head, wherein said ink consumption condition in said ink container is detected using a piezo-electric device having a piezo-electric element, said method comprising:

abstaining from jetting ink drops from said recording head in a non-recording state; and

measuring a periodic peak value of a waveform of counter electromotive force during a maintenance operation for cleaning out ink in said recording head, wherein said periodic peak value is generated by a residual vibration remaining in a vibration part by a predetermined number of said periodic peak values from a predetermined point of time, such that when said piezo-electric device measure more number of said periodic peak values than said predetermined number of said periodic peak values in subsequent detection of said ink consumption condition, said ink consumption condition is thereby detected.

67. (previously presented) An ink consumption condition detection method for detecting an ink consumption condition in an ink container loaded in an ink jet recording apparatus having a recording head for jetting ink drops, the method comprising:

cleaning out ink in said recording head during a maintenance operation; and

detecting said ink consumption condition using a piezo-electric device having a piezo-electric element, during said maintenance operation.

68. (previously presented) An ink jet recording apparatus according to claim 46, wherein said piezo-electric device has a piezo-electric layer and an electrode disposed between said piezo-electric layer and said vibrating plate.

69. (previously presented) An ink jet recording apparatus according to claim 54, wherein said piezo-electric device has a piezo-electric layer, a vibrating plate and an electrode disposed between said piezo-electric layer and said vibrating plate.

70. (previously presented) An ink jet recording apparatus according to claim 56, wherein said piezo-electric device has a piezo-electric layer, a vibrating plate and an electrode disposed between said piezo-electric layer and said vibrating plate.

71. (previously presented) An ink jet recording apparatus according to claim 59, wherein said piezo-electric device has a piezo-electric layer, a vibrating plate and an electrode disposed between said piezo-electric layer and said vibrating plate.